

Renew the Government

Summary of Projects and Lessons Learned

U.S. Department of Energy • Sandia National Laboratories • Bureau of Land Management National Park Service • USDA Forest Service





RENEW THE GOVERNMENT SUMMARY OF PROJECTS AND LESSONS LEARNED

ACKNOWLEDGMENTS

A special thanks goes to Jim Rannels, DOE Office of Photovoltaic and Wind Technology, and Anne Sprunt Crawley, DOE Federal Energy Management Program, without whose support the Renew the Government effort would not have been possible. We also wish to express our appreciation to Doug DeNio, National Park Service (retired), and Fred Bloom, formerly Tonto National Forest, for their commitment and enthusiasm in setting the groundwork that allowed this effort to go forward. Gabriella Cisneros and Vern Risser of the Southwest Technology Development Institute helped develop the project information database. Anne Van Arsdall and Connie Brooks, Sandia National Laboratories, provided significant editorial assistance and Subia was responsible for the publication design. Our biggest thanks, however, goes to the many Park, BLM, and Forest participants who chose to get involved in using photovoltaics and to the U.S. photovoltaics industry who provided the quality systems that made this endeavor successful.

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Tonto National Forest USDA Forest Service

ABSTRACT

For the past several years, the Photovoltaic Systems Assistance Center at Sandia National Laboratories has maintained collaborative partnerships with the National Park Service, Bureau of Land Management, and USDA Forest Service. The purpose of these partnerships is to establish the sustainable use of photovoltaic technology in the agencies. Through the partnerships, assessments of applications and acceptance of photovoltaics were completed within each agency to establish benchmarks. Based on the results of these assessments, 122 new projects were developed and installed. This report documents these newer projects and identifies the lessons learned through these partnership activities.

INTRODUCTION

In October 1992, the National Park Service (NPS) released the document *Guiding* Principles of Sustainable Design to provide a framework for achieving sustainability in all national park operations and development activities. Energy management was identified as a major component of sustainable design. The NPS subsequently specified the use of renewable energy sources as a key strategy in the overall effort to develop sustainable energy management. In 1993, the NPS and the US Department of Energy Office of Photovoltaic and Wind Technology, through the Photovoltaic Systems **Assistance Center at Sandia National** Laboratories, entered into a collaborative partnership to promote energy conservation and increase the use of renewable energy at all NPS facilities.

Additional partnerships were developed with the USDA Forest Service in 1994 and the Bureau of Land Management in 1995, all with the central focus of expanding the use of renewable energy, specifically photovoltaics. The three partnerships – Renew the Parks, Renew the Forests and Renew the Public Lands – followed a common approach. Each agency conducted extensive surveys to assess existing applications, customer satisfaction, and barriers to increased

usage. In addition, potential opportunities for photovoltaics to meet existing power needs as well as future power needs were identified. The findings were documented in three publications:

Renew the Parks -

Renewable Energy in the National Park Service – Photovoltaic Systems, 1995

Renew the Forests -

Photovoltaic Technology in the USDA Forest Service, 1996

Renew the Public Lands –

Photovoltaic Technology in the Bureau of Land Management, 1996

Pilot projects, representative of the power needs identified in the assessments, were developed to increase agency familiarization and acceptance. One hundred twenty-two projects are in various stages of deployment and on schedule to be completed as planned. The processes involved in these projects include all phases of system definition, design, procurement, installation, and acceptance, all of which are described in this report.

PILOT PROJECTS

A total of 122 collaborative agency projects located in 23 states have been developed so far. These include 73 parks, forests, and BLM districts, as shown below. The projects are representative of the applications already being powered by photovoltaic systems, but with a focus on those applications that meet future agency needs. By agency, the numbers of projects are:

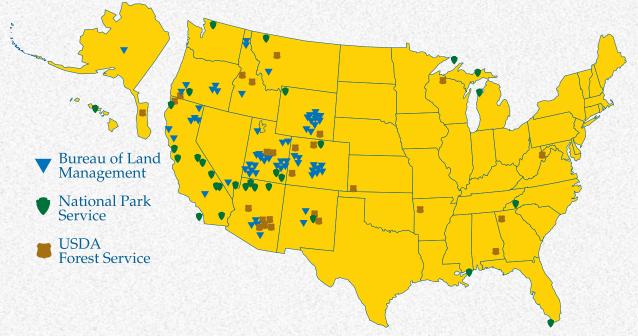
- National Park Service 30
- USDA Forest Service 27
- Bureau of Land Management 65

The largest project is a 115-kW NPS facility power system at Dangling Rope Marina in Glen Canyon National Recreation Area, Utah. The smallest project is a 10-watt BLM water monitoring system on a Weather Station/Rain Gauge in Utah. The total rated

photovoltaic array power for all projects is approximately 313 kW, broken down as follows:

- National Park Service 247 kW
- USDA Forest Service 20 kW
- Bureau of Land Management 46 kW

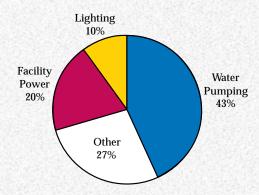
Most of the NPS systems are in the range of 5 to 20 kW and provide power to various park facilities. The primary goal of *Renew the Parks* is to replace existing diesel-fueled engine generators. This application accounts for the substantial number of photovoltaic systems installed at remote NPS facilities. The Forest Service and BLM systems are all less than 5 kW in size, typically 1 kW or smaller, and focus on recreational development/campground power and water pumping.



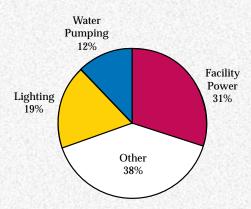
PROJECT SUMMARY

The projects in this document are divided into three major categories of applications: photovoltaics for *facility power, lighting*, and *water pumping*. These categories were selected based on information obtained from the BLM, USDA Forest Service, and NPS on the future applications for photovoltaics they anticipate, shown in the accompanying pie charts. The "other" category in the pie charts includes communications, remote monitoring, warning signs, gate openers, and other miscellaneous uses, none of which is numerically significant across the agencies.

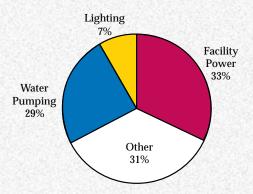
Project data sheets with general information and remarks are included in Appendix I for each system. The information provided includes the site, location, agency owner, installation date, system supplier, installer, system type, array size, types of components, component manufacturers, and information on the electrical load, system cost, and agency contact for the project. The general comments section contains operational information, such as data on the operation and maintenance of the system, performance assessment, unique features, etc. The projects are listed in an index in Appendix III, organized by application, agency, state and district.



Future Use of PV Power - BLM



Future Use of PV Power - NPS



Future Use of PV Power - USDA Forest Service

LESSONS LEARNED

Several lessons have been learned through the processes of implementing these projects. Some are associated with specific agency processes, such as procurement and installation. Others are relevant to photovoltaic systems in general, such as design, installation, maintenance, vandalism, and cost.

The lessons learned are grouped into four major categories:

- Feasibility
- Procurement
- Operation and Maintenance
- Value

Feasibility

The first question typically raised about any of the projects is very simply, "Does it make sense to use photovoltaics?" Each of the pilot projects went through a detailed assessment, many conducted on-site by a partnership team, to determine what was needed, what was available, and what could be done. The lesson learned is:

The agency must determine what it needs before it procures anything.

The experience of the *Renew* partnerships is that the agencies require significant technical assistance before they can make informed decisions. Although there has been increased familiarization with

photovoltaic technology, and pockets of expertise within each agency do exist, continued assistance will be required before a sustainable process is in place.

In addition, without enthusiastic support from agency personnel, expanded use of photovoltaics within an agency will remain near zero. The lesson learned is:

> A project advocate for photovoltaics must exist in the agency and must be in a position to affect decisions.

As a first step, each *Renew* partnership identified an agency coordinator as an advocate for the technology and a point of contact for other agency personnel. For *Renew the Parks*, the NPS Denver Service Center serves this role. Tonto National Forest serves the same role for *Renew the Forests*, and the Utah State BLM Office coordinates all activities for *Renew the Public Lands*. The experience gained through implementing the pilot projects provided more agency personnel with hands-on training.

Procurement

Although no one procurement process has proven to be best in all cases, experience with these projects shows a number of common features that are consistent with success and sustainability. In short, know

what you need, adequately specify it, standardize the procurement, and purchase multiple systems.

The procurement processes varied greatly on these projects. To emphasize sustainability, the *Renew* partnerships required that the projects be procured via typical agency processes. Nevertheless, the typical options encompassed various approaches, some more successful than others, including:

- 1. Photovoltaic industry competitively bids on design and building of systems.
- 2. Agency specifies systems and issues competitive general contract; photovoltaic industry sub-contractor supplies hardware and installation.
- 3. Agency specifies systems; GSA procures; agency installs systems.
- 4. Photovoltaic industry designs systems and uses agency-procured hardware and installation.
- 5. Agency uses an energy provider (utility) contract with a turn-key installation.

Early on in the partnership procurements, general functional system specifications were used with the idea that potential suppliers would have substantial flexibility in sizing, designing and providing photovoltaic systems. These

elements are included in options 1, 4, and 5 above. These approaches did not work well, in part because of inappropriate systems being proposed, but more often because the specifications didn't really cover the agency's needs and desires. More success was seen in approaches 2 and 3, which required more agency interest and direct involvement. The lesson learned is:

A system should be adequately specified before it is procured, and the agency must be directly involved.

Standardizing the procurement of photovoltaic systems for smaller applications such as water pumping, campground host site power, and small remote facilities has resulted in substantial benefit; i.e., the agencies are able to get what they need at the least cost. The lesson is:

The procurement of standardized photovoltaic systems through standardized specifications and standardized processes greatly benefits the agency.

Sample procurement specifications that incorporate these lessons learned are included in Appendix II. Although each individual agency unit, such as a park or forest, can procure a system, the *Renew* experience with packaged procurements

of multiple systems has been very positive. The lesson learned is:

Packaged procurements of standardized systems for multiple agency sites through a centralized office have proven to be very successful.

Operation and Maintenance

Although familiarity with photovoltaics among agency personnel is slowly increasing, a sizeable segment of the general public is quite aware of the value of photovoltaic modules, batteries, etc. In the past, vandalism such as breakage and other damage to photovoltaic systems was far too common, especially in remote areas. In today's world, theft is the problem. This issue is no different for photovoltaics than for any other improvements made at a remote site. Although the use of vandal-resistant hardware, coupled with elevated or difficult-to-access arrays, may slow down the dedicated thief, the BLM has noted that a host at a remote site can reduce vandalism to near zero. The BLM has a backlog of willing volunteer hosts. An attractive way to induce a host to locate at a remote campground is to install a photovoltaic system to provide the host with electrical amenities, with an almost immediate payback, a win-win situation.

The lesson learned is:

Providing power to a site host is an effective way to prevent theft and other vandalism at a remote site.

Another very important lesson concerns the cost of maintenance for photovoltaic systems. Detailed performance and economic analyses based on two years of actual operation have been conducted on three of the photovoltaic hybrid/engine generator systems documented in this report. These three systems are Rogers Peak, Figure 1; Pinnacles National Monument, Figure 2; and Dangling Rope, Figure 3. Conventional thinking is that the hybrid photovoltaic system has a high initial capital cost (compared only with an engine generator system) but the maintenance cost is very low. Although in general this argument is true, the use of batteries in hybrid photovoltaic systems cannot be overlooked in planning for future costs. For the three systems noted, recurrent maintenance and capital

replacement cost represent 14% to 25% of the life-cycle cost of the hybrid system, primarily because of the batteries. The lesson learned is:

The cost of battery replacement in photovoltaic systems must be included in planning for future maintenance costs for the system.



Figure 1. Rogers Peak.

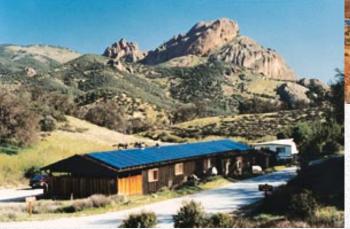


Figure 2. Pinnacles National Monument.



Figure 3. Dangling Rope.

Value

A frequently asked question is, "Should I use photovoltaics for this application?" Although photovoltaics offers significant advantages over competing power options in many cases, it may not always provide the best value for the agency. For the pilot projects documented in this report, photovoltaics was deemed to provide the best value to the procuring agency in every case. That doesn't necessarily mean it was the lowest cost option, or even the most convenient; however, it was the option with the most value. The lesson learned is:

Successful projects are those that are based on the best value, taking into consideration environmental concerns, quality of life, energy security, educational opportunities, lowest first costs, lowest life-cycle costs, etc.

An equally important lesson is:

Viable photovoltaic projects are typically for remote applications where the cost of photovoltaics is compared against other remote power options.

The *Renew* partnerships involve the NPS, BLM and Forest Service for one very important reason - these three agencies have jurisdiction over 25% of the land area in the USA. The opportunities are huge for photovoltaics to provide power for recreational development and resource management in this vast area. Federal agencies have a significant opportunity to expand their use of photovoltaics where they have needs for remote power and where photovoltaic systems can provide the best value option. Recent experience with grid-tied photovoltaic procurements shows that the levelized energy cost is \$0.25 to \$0.30 per kWh of electrical

generation under the most favorable economic conditions. Costs for standalone hybrid photovoltaic systems, on the other hand, are \$0.40 per kWh to more than several dollars per kilowatt-hour. Today's economics offer limited opportunity for photovoltaics to compete on a cost basis with conventional grid-tied electricity. Where photovoltaics can compete and offers the highest value is at sites off the utility grid or at sites where the existing engine generators are run very inefficiently and/or have significant environmental problems with fuel spills or atmospheric emissions. The lesson learned is:

Energy savings cannot be used to justify the cost of the photovoltaic project; economic justification must be based on comparison with alternative energy options.











CONCLUSIONS

The Renew the Government Program identified potential use of photovoltaic technology within the NPS, the BLM, and the USDA Forest Service that was consistent with the principles of sustainable design and would provide significant value to those agencies and the American public. Through the collaborative efforts of those agencies and the Photovoltaic Systems Assistance

Center at Sandia National Laboratories, a large number of pilot systems are being used and evaluated by the agencies and the public. Our hope is that continued positive reaction, maintenance-cost reductions, and environmental benefits will eventually result in the sustained use of photovoltaics in these and other federal organizations where it makes sense.

"The agency must determine what it needs before it procures anything."

"A project advocate for photovoltaics must exist in the agency and must be in a position to affect decisions."

"A system should be adequately specified before it is procured, and the agency must be directly involved."

"The procurement of standardized photovoltaic systems through standardized specifications and standardized processes greatly benefits the agency."

"Packaged procurements of standardized systems for multiple agency sites through a centralized office have proven to be very successful." "Providing power to a host site is an effective way to prevent theft and other vandalism at a remote site."

"The cost of battery replacement in photovoltaic systems must be included in planning for future maintenance costs for the system."

"Successful projects are those that are based on the best value, taking into consideration environmental concerns, quality of life, energy security, educational opportunities, lowest first costs, lowest life-cycle costs."

"Viable photovoltaic projects are typically for remote applications where the cost of photovoltaics is compared against other remote power options."

"Energy savings cannot be used to justify the cost of the photovoltaic project; economic justification must be based on comparison with alternative energy options."

Appendix I

Pilot Project Data Sheets

Facility Power







Bureau of Land Management • National Park Service • USDA Forest Service







ALASKA

Northern District



Chicken Field Station

Kent Davis

Contact Person

(907) 883-5121

Contact Number

\$13,374 (hardware only)

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 1,280 W Solarex

batteries 25 kWh Valve Regulated Deka

controller Pulse Energy Systems

inverter SW 4048 Trace Engineering

loads Bunk Houses (3)





ARIZONA

Arizona Strip District

Mt. Trumbull Administration Site



ARIZONA

Tucson District



San Pedro

Ken Moore

Contact Person

(435) 628-4491

Contact Number

\$30,169 (hardware only)

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

October 1998

Installation Date

System Components:

array 2,560 W Solarex

batteries 62 kWh Valve Regulated GNB

controller Pulse Energy Systems

inverter SW 5548 (2) Trace Engineering

generator 6.5 kW Onan Propane

loads Duplex, Shop, and Bunk House

Dorothy Morgan

Contact Person

(520) 458-3559

Contact Number

\$37,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

December 1997

Installation Date

System Components:

array 1,100 W Solarex

batteries 73 kWh Flooded C&D

controller Ananda Power Technologies inverter SW 4048 Trace Engineering

generator 10 kW Kohler Propane





CALIFORNIA

Bakersfield District



Chimney Peak

Glen Yamashita

Contact Person

(805) 391-6046

Contact Number

\$30,169 (hardware only)

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 2,560 W Solarex

batteries 62 kWh Valve Regulated GNB

controller Pulse Energy Systems

inverter SW 5548 (2) Trace Engineering

generator 70 kW Kohler Propane

loads Barracks, Office and Shop Buildings

CALIFORNIA

Eagle Lake Resource Area

Hobo Camp



Don Wannebo

Contact Person

(916) 257-0456

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site





CALIFORNIA

Eagle Lake Resource Area



Rocky Point

Don Wannebo

Contact Person

(916) 257-0456

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

CALIFORNIA

Surprise Resource Area

Massacre Camps



Rudy Tafoya

Contact Person

(916) 279-6101

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

July 1997

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site





CALIFORNIA

Surprise Resource Area

> Yellow Peak Lookout



Rudy Tafoya

Contact Person

(916) 279-6101

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

July 1997

Installation Date

System Components:

array 384 W Solarex

batteries 6.3 kWh Valve Regulated Deka

controller Morningstar

inverter 1,500 W Trace Engineering

General Comments:

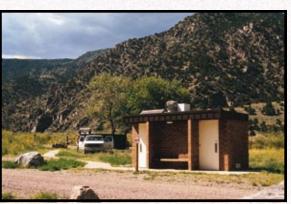
Radio repeater and lookout.

• After the photovoltaic installation, there is now a waiting list of volunteers to man the lookout.

COLORADO

Canon City District

Five Points Campground



Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$3,600

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

System Components:

array 120 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and I

Entrance Signs and Restroom Lighting





COLORADO

Canon City District

Five Points Recreation Area



COLORADO

Canon City District

Hecla Junction Recreation Area



Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$2,700

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$4,500

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

System Components:

array 90 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and Restroom Lighting

System Components:

array 150 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and Restroom Lighting





COLORADO

Canon City District



Phantom Canyon

Gordon Gardunio

Contact Person

(970) 244-3186

Contact Number

\$500 per system

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

September 1998

Installation Date

System Components:

array 20 W Solarex MSX-20 loads 100 CFM 12 Vdc Fan

General Comments:

• 4 systems installed on vault toilets.

COLORADO

Canon City District

Railroad Bridge Recreation Area



Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$2,700

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

System Components:

array 90 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and Restroom Lighting





COLORADO

Canon City District

Rincon Recreation Area



COLORADO

Canon City District

Ruby Mountain Recreation Area



Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$3,600

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

System Components:

array 120 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and Restroom Lighting

Dave Taliaferro

Contact Person

(719) 539-7289

Contact Number

\$5,400

PV System Cost

Photocomm

System Supplier

BLM/Colorado State Parks

System Installer

August 1997

Installation Date

System Components:

array 180 W Uni-Solar

batteries Valve Regulated Deka controller Trace Engineering

loads Entrance Signs and Restroom Lighting





COLORADO

Grand Junction
District

Mud Springs



COLORADO

Montrose District



Mill Creek

Joe Ashor

Contact Person

(970) 224-3031

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

June 1997

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

Gordon Gardunio

Contact Person

(970) 244-3186

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site





IDAHO

Boise District



Mud Flat

NEW MEXICO

Albuquerque District

Orilla Verde



Bob Stucker

Contact Person

(208) 384-3300

Contact Number

\$17,890 (hardware only)

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

September 1998

Installation Date

Steve Jordan

Contact Person

(505) 438-7440

Contact Number

\$4,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

2,048 W Solarex array

38 kWh Valve Regulated Deka batteries

controller Pulse Energy Systems

SW 5548 Trace Engineering inverter loads

Bunk Houses (2) and Well Pump

System Components:

231 W Solarex array Flooded GNB batteries controller Morningstar

Trace Engineering inverter **Trailer Mounted** other

Campground Host Site loads

General Comments:

Two systems at site.





NEW MEXICO

Socorro District



Fort Craig

Steve Jordan

Contact Person

(505) 438-7440

Contact Number

\$45,000

PV System Cost

Socorro Electric Coop./PSN

System Supplier

Direct Power and Water

System Installer

January 1998

Installation Date

System Components:

array 2,000 W Solarex

batteries 56 kWh Flooded Deka controller Pulse Energy Systems

inverter SW 5548 (2) Trace Engineering

generator 10 kW Kohler Propane

loads Site Host, Restroom Lighting

OREGON

Burns District

Riddle Brothers Ranch



Fred McDonald

Contact Person

(541) 573-4453

Contact Number

\$17,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

July 1997

Installation Date

System Components:

array 640 W Solarex

batteries 25 kWh Flooded Trojan controller Ananda Power Technologies

inverter SW 4048 Trace Engineering

loads Remote Residence

General Comments:

Seasonal use.

Sunfrost refrigerator.





OREGON

Burns District

South Steens Campground



OREGON

Medford District



Rogue River Ranch

Fred McDonald

Contact Person

(541) 573-4453

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

John Bethea

Contact Person

(503) 770-2246

Contact Number

\$26,788 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 1,326 W Siemens and Solarex

batteries 33.6 kWh Flooded Trojan controller Ananda Power Technologies inverter SW 4024 Trace Engineering

other 2-Nozzle Harris Hydroelectric Pelton Wheel

300 W Southwest Wind Power Wind Generator

loads Remote Residence and Contact Station

General Comments:

• Article in Issue #55, Home Power Magazine.





UTAH

Cedar City District

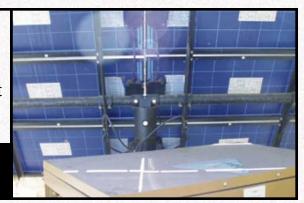
Baker Dam Campground



UTAH

Cedar City District

Ponderosa Grove Campground



R.J. Hughes

Contact Person

(801) 628-4491

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

Janaye Byergo

Contact Person

(801) 586-2401

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

June 1997

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site





UTAH

Cedar City District

Red Cliffs Campground



UTAH

Moab District

Big Bend Campground



R.J. Hughes

Contact Person

(801) 628-4491

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

John Lewis

Contact Person

(801) 259-2100

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host site

General Comments:

• System provides year-round power for campground host.





UTAH

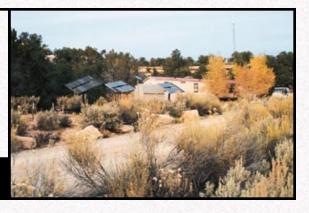
Moab District

Goose Island Campground



UTAH

Moab District



Kane Gulch

John Lewis

Contact Person

(801) 259-2100

Contact Number

\$6,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 384 W Solarex

batteries 5.8 kWh Valve Regulated GNB

controller Morningstar

inverter 1,500 W Trace Engineering

other Trailer Mounted

loads Campground Host Site

Trent Duncan

Contact Person

(801) 539-4090

Contact Number

\$30,000

PV System Cost

Solar Power/Applied Power

System Supplier

Bureau of Land Management

System Installer

October 1995

Installation Date

System Components:

array 2,000 W Siemens

batteries 84 kWh Valve Regulated GNB controller Ananda Power Technologies inverter SW 4048 Trace Engineering

generator 12 kW

other Zomeworks Tracker

- Remote residence/ contact station.
- Seasonal use. Trailer mounted array is removed from site during winter months.





UTAH

Moab District

Sandwash Ranger Residence



UTAH

Vernal District

Pariette Administrative Site



Dennis Willis

Contact Person

(801) 636-3600

Contact Number

\$20,000

PV System Cost

Solar Power/Applied Power

System Supplier

Bureau of Land Management

System Installer

July 1995

Installation Date

System Components:

array 1,320 W Siemens

batteries 84 kWh Valve Regulated GNB controller Ananda Power Technologies inverter 1,500 W Trace Engineering

other Zomeworks Tracker loads Remote Residence

General Comments:

- Daily energy use 5 kWh.
- · Seasonal use.
- Trailer-mounted arrays are removed from site during winter months.
- Batteries installed in underground vault to moderate temperature.

John Wood

Contact Person

(435) 781-4400

Contact Number

\$14,000

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

September 1998

Installation Date

System Components:

array 1,024 W Solarex

batteries 25 kWh Valve Regulated Deka

controller Pulse Energy Systems

inverter SW 4048 Trace Engineering

loads Remote Residence

- · Year round use.
- Maintenance and lodging facility for the Pariette Wetlands.





UTAH

Vernal District



South Camp

Gary Hunter

Contact Person

(801) 741-4400

Contact Number

\$6,000

PV System Cost

Solar Power

System Supplier

Bureau of Land Management

System Installer

August 1995

Installation Date

System Components:

array 330 W Siemens

batteries 12.7 kWh Valve Regulated Deka controller Ananda Power Technologies inverter 2,500 W Trace Engineering

generator 4 kW Onan Propane loads Remote Residence

- Seasonal use.
- Daily energy use 1 kWh.
- Water Pumping.







ARIZONA

Grand Canyon National Park



Cottonwood

Curt Edlund

Contact Person

(520) 638-7730

Contact Number

\$14,600

PV System Cost

Applied Power/Utility Power

System Supplier

National Park Service

System Installer

April 1995

Installation Date

System Components:

array 720 W Solarex MSX-60 batteries 25 kWh Trojan L-16

inverter SW 4024 Trace Engineering

generator 300 W Pelton Wheel other Zomeworks Tracker

loads Typical Residential, including Evaporative

Cooler, and Sunfrost Refrigerator





ARIZONA

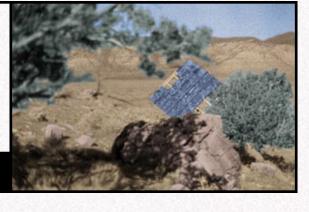
Grand Canyon National Park





ARIZONA

Grand Canyon National Park



Tuweep

Curt Edlund

Contact Person

(520) 638-7730

Contact Number

\$27,500

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

October 1995

Installation Date

System Components:

array 1,440 W Solarex MSX-60

inverter SW 5548 (2) Trace Engineering

other Grid-Tied, Garfield-Kane County Rural

Electric

loads Area Lighting Display, Lighting and

Computers

General Comments:

- Provides power to visitor center.
- Building heat and water heating use propane.

Curt Edlund

Contact Person

(520) 638-7730

Contact Number

\$24,500

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

April 1995

Installation Date

System Components:

array 1,200 W Solarex MSX-60 batteries 33.6 kWh Trojan L-16

inverter SW 4024 (2 stacked) Trace Engineering

generator 12 kW Propane

other Wattsun Dual Axis Tracker

loads Typical Residential, including Evaporative

Coolers, and Sunfrost Refrigerator

General Comments:

 Lightning strike disabled one inverter. Prompt repairs by Trace Engineering.





ARIZONA

Navajo National Monument



Rose Clark

Contact Person



Applied Power Corporation

System Supplier

(520) 672-2366 National Park Service

-Contact Number System Installer

\$10,000 October 1996

PV System Cost Installation Date

System Components:

array 512 W Solarex

batteries Valve Regulated GNB

controller Ananda Power Technologies

inverter Trace Engineering

loads Remote Ranger Residence and Contact

Station

General Comments:

Seasonal use.

CALIFORNIA

Channel Islands National Park

Santa Rosa Island



Kent Bullard

Contact Person

(805) 658-5745

Contact Number

\$300,000

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

April 1997

Installation Date

System Components:

array 12,000 W Siemens

batteries Flooded GNB inverter 30 kW Abacus generator 30 kW Diesel

- Project received Federal Energy Efficiency Fund Grant from U.S. DOE.
- Includes 2 10-kW Bergey wind turbines.
- All islands in the park are PV powered.





CALIFORNIA

Death Valley National Park

Rogers Peak



Tom Ward

Contact Person

(714) 870-3175

-Contact Number

\$287,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

July 1994

Installation Date

System Components:

array 12,840 W Solarex

batteries Valve Regulated GNB

controller Applied Power Corporation

generator 35 kW Onan Propane

charger La Marche

loads 24 Volt Communication

General Comments:

- Owned and operated by Southern California Edison.
- PV has produced 93% of site energy.
- 1,700 W of continuous load.
- No downtime in 3 years of operation.
- Engine run-time limited to 250 hours per year.

CALIFORNIA

Golden Gate National Recreation Area

Presidio, Thoreau Center



Jim Christianson

Contact Person

(415) 561-4352

Contact Number

\$27,000

PV System Cost

Atlantis Energy

System Supplier

Atlantis Energy

System Installer

March 1997

Installation Date

System Components:

array 2,000 W Solarex inverter Trace Engineering

other Grid-Tied

loads All Building Loads for a Non-profit

Organization

- Array was custom fabricated to fit inside glass canopy entry way.
- Collaborative project with Federal Energy Management Program.





CALIFORNIA

Joshua Tree National Park

Cottonwood



CALIFORNIA

Kings Canyon National Park

Hole-in-the-Wall



Harry Carpenter

Contact Person

(619) 367-7464

Contact Number

\$266,300

PV System Cost

Southern California Edison

System Supplier

Utility Power Group

System Installer

October 1998

Installation Date

System Components:

array 20,000 W Siemens

batteries C&D Flooded

inverter 20 kW Trace Technologies generator 30 kW Kohler Propane

General Comments:

 System provides power for a visitor center, maintenance facility, several residences and a campground. Pete Lucero

Contact Person

(209) 335-2860

-Contact Number

\$105,000

PV System Cost

BP Solar

System Supplier

Pro-Control

System Installer

September 1998

Installation Date

System Components:

array 8,000 W BP Solar

batteries 144 kWh Valve Regulated controller C40 Trace Engineering

inverter SW 5548 (2) Trace Engineering

generator 20 kW Propane

General Comments:

System powers a remote trail maintenance facility.





CALIFORNIA

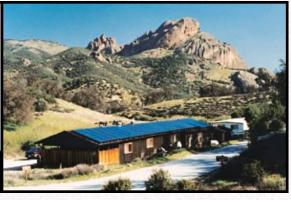
Mojave National Preserve

Hole-in-the-Wall Visitor Center



CALIFORNIA

Pinnacles National Monument



Chaparral

Dave Paulissen

Contact Person

(760) 255-8810

Contact Number

\$106,020

PV System Cost

S. Cal. Edison/UPG

System Supplier

S. Cal. Edison/UPG

System Installer

Planned December 1998

Installation Date

System Components:

array 4,200 W Siemens

batteries 111 kWh C&D Valve-Regulated Lead-Acid

controller Pulse Energy Systems inverter 5548 (2) Trace Engineering generator 10 kW Kohler Propane

generator 10 kW Kohler Propane other K-rail Support Structure

Debby Simmons

Contact Person

(408) 389-4485

-Contact Number

\$135,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

March 1996

Installation Date

System Components:

array 9,600 W Solarex

batteries 200 kWh Valve Regulated GNB controller Ananda Power Technologies inverter SW 4048 (6) Trace Engineering

generator 20 kW Kohler Propane

other Southwest Technology Development

Institute Data Acquisition System

- Engine run-time less than 800 hours per year.
- PV supplies 100% of energy needs during summer months.
- Daily energy use between 35 and 40 kWh.
- No downtime since system installation.





MICHIGAN

Isle Royale National Park

Davidson Island



MICHIGAN

Pictured Rocks National Lakeshore

> Au Sable Light Station



Andrew Bilton

Contact Person

(906) 487-7166

Contact Number

\$10,000 (hardware only)

PV System Cost

SunWize Technologies, Inc.

System Supplier

National Park Service

System Installer

August 1998

Installation Date

System Components:

array 600 W Siemens

batteries Valve Regulated Concorde

controller Trace Engineering inverter Trace Engineering

generator 15 kW Onan Diesel Genset

loads Lights, Computers, Water Pump, Laboratory,

and Small Appliances

Chris Case

Contact Person

(906) 387-2607

Contact Number

\$75,000

PV System Cost

Currin Corporation

System Supplier

National Park Service

System Installer

Under Construction

Installation Date

System Components:

array 4000 W Siemens SP75

batteries 65 kWh Valve Regulated GNB inverter SW 5548 (2) Trace Engineering

- Array located 750 feet away from historic lighthouse.
- System includes geothermal heating system.





MICHIGAN

Sleeping Bear Dunes National Lakeshore



Dan Kreiber

(616) 326-5134

Contact Person

-Contact Number

PV System Cost



Currin Corporation

System Supplier

National Park Service

System Installer

September 1996

Installation Date

System Components:

\$110,000 (hardware only)

array 11,200 W Siemens Solar batteries Valve Regulated GNB

controller Ananda Power Technologies

inverter AES

generator 30 kW Diesel

General Comments:

Seasonal operation.

MISSISSIPPI

Gulf Islands National Seashore

Horn Island

Joe Martin

Contact Person

(404) 562-3257

Contact Number

\$60,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

September 1998

Installation Date

System Components:

array 3,600 W ASE

batteries GNB Sunlyte, flooded

inverter SW 5548 (2) Trace Engineering

generator 30 kW Kohler, Diesel (2)

other Lightning Arrestor

loads Residence, Maintenance Building, Water

Pumping

- PV system designed to handle winter loads without generators.
- Air conditioning loads during the summer are impractical to handle with PV.





MONTANA

Glacier National Park

Goat Haunt Visitor Center



NEVADA

Lake Mead National Recreation Area

Shivwits



Jerry Burgess

Contact Person

(406) 888-7974

-Contact Number

\$45.800

PV System Cost

Applied Power Corporation

System Supplier

Quantum Electric

System Installer

October 1998

Installation Date

System Components:

array 1,280 W Solarex MSX-64
batteries Valve Regulated GNB
controller Pulse Energy Systems
inverter Trace Engineering

General Comments:

- · Roof-mounted array.
- Seasonal operation.

Richard Lassiter

Contact Person

(702) 293-8745

Contact Number

\$23,000 (hardware only)

PV System Cost

Trace Engineering/Siemens

System Supplier

National Park Service

System Installer

August 1997

Installation Date

System Components:

array 1,200 W Siemens

batteries 350 A-h Flooded Lead Acid inverter 120/240 V Trace 4024 (2)

generator 20 kVA Onan Propane Fueled

loads Well Pump, Furnace Motors, and Lights

- Seasonal operation April through October.
- · Users extremely satisfied.
- System installation provided training activity for NPS personnel.





NEW MEXICO

Salinas Pueblo Missions National Monument

> Gran Quivira Visitor Center



OREGON

Crater Lake National Park

North Entrance Kiosk



Mike Schneegas

Contact Person

(505) 847-2585

-Contact Number

\$20,000

PV System Cost

Springer Electric Cooperative

System Supplier

Direct Power and Water

System Installer

June 1997

Installation Date

System Components:

array 1,440 W Solarex

batteries Valve Regulated Deka

controller Ananda Power Technologies

inverter Trace Engineering

other Grid-Tied

General Comments:

System provides enough energy for the facility.

 Three-cycle (recycled) building material used throughout the visitor center.

• Interactive computer display in the visitor center.

Brian Coulter

Contact Person

(503) 594-2211

Contact Number

\$8,000

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

September 1994

Installation Date

System Components:

array 360 W Solarex

batteries Flooded, Interstate L-16

controller Heliotrope (2)

inverter Prostar

loads Fans, Radios, Lighting (internal and external)

General Comments:

• Summer and Winter Modes (dual voltage).

Specialty Concepts, Inc. Monitoring Panel.





UTAH

Glen Canyon National Recreation Area

Dangling Rope Marina



UTAH

Natural Bridges National Monument

Visitor Center



Vic Knox

Contact Person

(602) 645-2471

-Contact Number

\$1,350,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

August 1996

Installation Date

System Components:

array 115,000 W ASE 300-DG/50 batteries 24 MWh C&D 6-C125-25 controller Kenetech Windpower

inverter 3ø 480 V Kenetech HY250

generator 250 kVA Caterpillar 3408 Propane

charger Inverter-Charger

other Southwest Technology Development

Institute Data Acquisition System

General Comments:

- Provides power to mini-grid/village power system.
- The loads are the fuel dock, marina store, refrigeration, and two dozen residence cabins.
- The total load for 1996/1997 was 438 MWh.
- Project developed in collaboration with Utah Energy Office,
 Federal Energy Management Program, and Utah Power and Light.

Bob Lovato

Contact Person

(435) 259-3911

Contact Number

\$156,000

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

May 1995

Installation Date

System Components:

array 15,600 W Solarex batteries C&D Flooded

controller MIT-Designed, Custom Intel

inverter 50 kVA Cyberex generator 120 kW Onan Diesel

loads Average 15 kW; 73,000 kWh/year, Includes 2

Deep Well Pumps, other Pumps

- Original system installed in 1980 was 100 kW.
- Battery replacement and array augmentation occurred in two phases: \$86,000 in October 1992 and \$70,000 in May 1995.





WASHINGTON

North Cascades National Park



Hozomeen

WYOMING

Yellowstone National Park

Lamar Buffalo Ranch



Steve James

Contact Person

(360) 873-4590

-Contact Number

\$168,000

PV System Cost

Applied Power Corporation

System Supplier

Dutton Electric

System Installer

May 1998

Installation Date

System Components:

array 7,200 W Solarex

batteries 48 kWh Absolyte - IIP GNB controller Ananda Power Technologies inverter SW 5548 Trace Engineering generator 25 kW Generac Propane

loads Two Duplex Housing Units, One Bunkhouse,

and One Maintenance Building

General Comments:

• Roof mounted system, custom designed, working very well.

• Recommended for more roof systems

Harold Anderson

Contact Person

(307) 344-2332

Contact Number

\$66,000

PV System Cost

Applied Power Corporation

System Supplier

National Park Service/NEOS

System Installer

July 1998

Installation Date

System Components:

array 6,500 W Solarex

batteries Valve Regulated Absolyte-IIP GNB

controller APT Power Center

inverter SW 4048 (2) Trace Engineering

generator 12 kW Kohler Propane

loads Residential (lighting and appliances)

General Comments:

Cost sharing through Federal Energy Management Program.







ALASKA

Tongass National Forest

Petersburg Ranger Dist. Crew Bldgs.



Tom Chittenden

Contact Person

(907) 772-5910

-Contact Number

\$7,500

PV System Cost

Photocomm

System Supplier

Tongass National Forest

System Installer

September 1997

Installation Date

System Components:

array 768 W Uni-Solar

batteries Valve Regulated Deka controller C40 Trace Engineering

inverter DR 1524 Trace Engineering other Whisper 600 Wind Generator

General Comments:

 This system provides power for crew buildings in a very remote area.





ARIZONA

Tonto National Forest

Schoolhouse Grove and Indian Point Campgrounds



ARIZONA

Tonto National Forest

Sunflower Environmental Center



Andrew Dziobek

Contact Person

(602) 225-5319

Contact Number

\$28,135

PV System Cost

Applied Power Corporation

System Supplier

Tonto National Forest

System Installer

September 1997

Installation Date

System Components:

array 180 W Solarex MSX-60 batteries Sunlyte #12-5000X

controller Prostar 30

General Comments:

There are 7 systems at this site.

Andrew Dziobek

Contact Person

(602) 225-5319

Contact Number

\$26,000

PV System Cost

Applied Power Corporation

System Supplier

Tonto National Forest

System Installer

Under Construction

Installation Date

System Components:

array 1,792 W Solarex MSX-64

batteries Valve Regulated GNB

controller Prostar-30 Morningstar; Grundfos Pump

Controller

inverter DR 1512 Trace Engineering

other 2 Zomeworks Trackers

loads Lights, Small Appliances, and Audio-Visual

Equipment; 1.5 HP Grundfos Submersible

Pump

General Comments:

• Power system supplies energy to remote environmental education center.





CALIFORNIA

Inyo National Forest

Schulman Grove Interpretive Site



COLORADO

Arapaho and Roosevelt National Forests

Mount Evans



John Louth

Contact Person

(760) 873-2514

-Contact Number

\$3,700

PV System Cost

Applied Power Corporation

System Supplier

Inyo National Forest

System Installer

September 1998

Installation Date

System Components:

array 384 W Solarex MSX-64

controller PPC-12-P Specialty Concepts Inc.

inverter DR 2412 Trace Engineering

loads Remote Visitor Center Lights and Cash

Register

Chris Ida

Contact Person

(970) 498-2742

Contact Number

\$4,000

PV System Cost

Comarco Wireless Technologies

System Supplier

Comarco Wireless Technologies

System Installer

August 1997

Installation Date

System Components:

array 18 W Solec

batteries Panasonic 12 V

loads Emergency Cellular Call Box





COLORADO

White River National Forest





IDAHO

Payette National Forest

Krassel Work Center



Rich Doak

Contact Person

(970) 925-3445

-Contact Number

\$16,000

PV System Cost

Sunsense

System Supplier

Sunsense

System Installer

Under Construction

Installation Date

System Components:

array 896 W Solarex MSX-64 batteries 19 kWh Trojan L-16 controller Pulse Energy Systems

inverter SW 4024 Trace Engineering

General Comments:

- System provides power to an entrance station.
- Heavily visited area with over 200,000 visitors per year.
- PV provides only power in the Maroon Valley/Maroon Lake area.
- Other PV projects include a PV-powered access gate, PV-powered composting toilets, and portable host-site power system.

Pat Trainor

Contact Person

(206) 253-0138

Contact Number

\$6,000

PV System Cost

Applied Power Corporation

System Supplier

Payette National Forest

System Installer

October 1995

Installation Date

System Components:

array 360 W Solarex MSX-60

batteries 6V Trojan Pacer L-16 Deep Cycle

controller 5TM/APT Powercenter

inverter U2512 SB Trace Engineering

loads Office Equipment/Light

General Comments:

• The system replaced 20-kW propane generator.





MONTANA

Lewis and Clark National Forest





Photocomm

System Supplier

(406) 466-5341

-Contact Number

Norm Kamrud

-Comact Numbe

Contact Person

\$8,000

PV System Cost

Lewis & Clark National Forest

System Installer

June 1996

Installation Date

System Components:

array 50 W Kyocera KC51
batteries IBE 75N23 Flooded
controller PSR-30 Photo Star
inverter 24-12 V Converter
loads Water Pump-24 V

General Comments:

- This system provides power for a work station in a very remote area.
- This system is also a water pumping system.

NEW MEXICO

Cibola National Forest



Doc Long

Mary Dereske

Contact Person

(505) 761-4650

-Contact Number

\$70,000

PV System Cost

AAA Solar

System Supplier

AAA Solar

System Installer

April 1996

Installation Date

System Components:

array 3,240 W Solarex batteries Flooded Trojan

controller Bobier

inverter Trace Engineering

loads AC and DC Loads; Host Site Power

General Comments:

• PV systems provide power for multiple restrooms, host-site, area lights, and group picnic shelter.





NEW MEXICO

Cibola National Forest

Sulphur Canyon



OREGON

Siskiyou National Forest

Big Pine Sightless Interpretive Trail



Mary Dereske

Contact Person

(505) 761-4650

Contact Number

\$15,000

PV System Cost

Direct Power and Water

System Supplier

Direct Power and Water

System Installer

May 1997

Installation Date

System Components:

array 768 W Solarex batteries Flooded Trojan controller Heliotrope

inverter Trace Engineering

other SEPCO Light at Host Site

loads AC and DC Loads; Host Site Power

Larry Cosby

Contact Person

(541) 471-6736

Contact Number

\$2,000

PV System Cost

Energy Outfitters

System Supplier

Siskiyou National Forest

System Installer

October 1995

Installation Date

System Components:

array 53 W Siemens M55

batteries 2 Trojan T-105

controller CC-10 Heliotrope General

loads Digital Speech Module DM 1000 LP-1

General Comments:

 System provides power for digital speech module along interpretive path.





UTAH

Manti-LaSal National Forest

Stuart Guard Station



Kathy O'Brian

Contact Person

(801) 637-2817

-Contact Number

\$6,500

PV System Cost

Applied Power Corporation

System Supplier

Manti-LaSal National Forest

System Installer

September 1998

Installation Date

System Components:

array 384 W Solarex MSX-64

batteries Gel Star

controller C40 Trace Engineering

inverter DR 1524 Trace Engineering

loads Lights, Small Power Tools, and Appliances

Lighting







Bureau of Land Management • National Park Service • USDA Forest Service







ARIZONA

Phoenix District

Burro Creek Recreation Site



Brenda Smith

Contact Person

(520) 757-3161

Contact Number

\$4,000

PV System Cost

Sun Amp

System Supplier

Bureau of Land Management

System Installer

April 1996

Installation Date

System Components:

array 256 W Solarex batteries Flooded Trojan loads Restroom Lights

General Comments:

• Site use heaviest in winter months.





IDAHO

Coeur d' Alene District

Mineral Ridge Boat Launch



Will Perry

Contact Person

(208) 769-5000

Contact Number

\$4.000

PV System Cost

Solar Outdoor Lighting

System Supplier

Bureau of Land Management

System Installer

May 1997

Installation Date

System Components:

150 W Solarex array

batteries 100 W Valve Regulated Deka

controller Solar Outdoor Lighting

loads Lights

General Comments:

· Lighting for boat tie-down area and ramp.

IDAHO

Coeur d' Alene District

Mineral Ridge Restroom



Will Perry Solar Outdoor Lighting

Contact Person System Supplier

(208) 769-5000 **Bureau of Land Management**

Contact Number System Installer

\$4,000 May 1997

PV System Cost Installation Date

System Components:

150 W Solarex array

batteries 100 W Valve Regulated Deka

controller Solar Outdoor Lighting

loads Lights and fan

General Comments:

· Restrooms' interior lights and vent fan.





NEVADA

Las Vegas District



Red Rocks Vista

Sal Estrada

(702) 647-5000

Contact Number

Contact Person

\$10,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

October 1996

Installation Date

System Components:

array 768 W Solarex batteries 10 kWh Flooded

controller Prostar

inverter 700 W Inverter

loads Restroom & Area Lights

General Comments:

 Central system with lights in restrooms and area lighting in parking lot.

 Occupancy sensors control lights in restroom timer controls area lights. **UTAH**

Cedar City District

Ponderosa Grove Campground



Janaye Byergo

Contact Person

(801) 586-2401

Contact Number

\$1,200

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 60 W

batteries Valve Regulated GNB controller C-12 Trace Engineering

loads 7 W Flourescent

General Comments:

• Two systems.





UTAH

Richfield District-Fillmore Field Office

Sand Mountain



Ferris Clegg

Contact Person

(435) 896-1500

Contact Number

\$3,000

PV System Cost

SEPCO

System Supplier

Silverado Company

System Installer

April 1998

Installation Date

System Components:

array 150 W Siemens

batteries 120 A-h Valve Regulated Geltech

controller SEPCO

loads 13 W Lights (5)

General Comments:

• Lights are used for 4 hours per night.

Building is used for spring, summer, and fall.

WYOMING

Rawlins District

Split Rock Interpretive Site



Roy Hanson

Contact Person

(307) 328-4317

Contact Number

\$1,000

PV System Cost

Solar Depot

System Supplier

Bureau of Land Management

System Installer

July 1996

Installation Date

System Components:

array 50 W Solarex

batteries 9 A-h Valve Regulated loads Lights and Vent Fan

General Comments:

· Vent fan operates daylight hours only.

 Three small commercial light packages operate on motion sensors.







CALIFORNIA

Redwood National Park



Redwood Creek

Bill Vines

Contact Person

(707) 464-6101

Contact Number

\$5,408

PV System Cost

Applied Power Corporation

System Supplier

National Park Service

System Installer

September 1998

Installation Date

System Components:

array 512 W Solarex

batteries 2.4 kWh Valve Regulated GNB

controller Ananda Powercenter 3

other Lightning Arrestor

loads 24 V Lights, Controlled by Photo Cells and

Occupant Sensors

- Powercenter 3 controller is expandable.
- Total load capacity is 136 W.





Colorado

Rocky Mountain National Park



Bear Lake

Ben Hawkins

Contact Person

(970) 586-1239

Contact Number

\$15,000 (hardware only)

PV System Cost

Sunelco

System Supplier

National Park Service

System Installer

Under Construction

Installation Date

System Components:

array 1,500 W

batteries Valve Regulated GNB

loads Restrooms and Contact Station



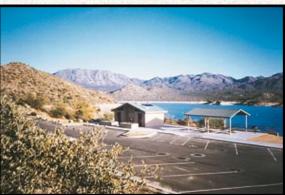




ARIZONA

Tonto National Forest

Rattlesnake Fishing Dock



Andrew Dziobek

Contact Person

(602) 225-5319

Contact Number

\$4,000

PV System Cost

Applied Power Corporation

System Supplier

Tonto National Forest

System Installer

Under Construction

Installation Date

System Components:

array 240 W Solarex MSX-60 batteries 12-5000 Sunlyte GNB controller C-12 Trace Engineering

loads 13 W Lights (4)

General Comments:

 Lights provide night-time access to floating fishing dock on Bartlett Reservoir.

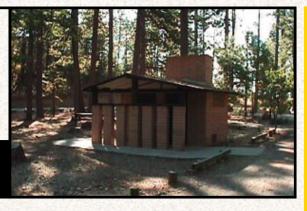




CALIFORNIA

Mendocino National Forest

Letts Lake Campground



COLORADO

Grand Mesa National Forest

Ward Creek



Fred Bell

Contact Person

(530) 934-3316

Contact Number

\$5,000

PV System Cost

Applied Power Corporation

System Supplier

Mendocino National Forest

System Installer

Under Construction

Installation Date

(970) 874-6600 Contact Number

\$1,000

Jan Fenner

Contact Person

PV System Cost

Johnson Electric Ltd.

System Supplier

Grand Mesa National Forest

System Installer

July 1995

Installation Date

System Components:

array 384 W Solarex MSX-64 batteries 12-5000 Sunlyte GNB controller ProStar-30C Morningstar

loads 13 W Lights (3) and 100-CFM Fans (2)

System Components:

array 60 W Solarex MSX-30 Lite

controller Sun Selector

loads Fans (2)

General Comments:

• Two systems installed on vault toilets.





GEORGIA

Chattahoochee **National Forest**





Contact Person

(770) 536-0541

Contact Number

Steve Ray

\$3,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Chattahoochee National Forest

System Installer

July 1998

Installation Date

System Components:

120 W Solarex MSX-60 array

12-5000 Valve Regulated GNB batteries

controller ProStar-12 Morningstar

other **Zomeworks Support Structure**

16 W Thinlite Lights loads

General Comments:

• The site has two identical systems, one per toilet building.

WYOMING

Medicine Bow National Forest

Little Brooklyn **Guard Station**



Dean Lebeda

Contact Person

(307) 745-2362

Contact Number

\$5,000

PV System Cost

Atlantic Solar Products

System Supplier

Medicine Bow National Forest

System Installer

September 1998

Installation Date

System Components:

256 W Solarex MSX-64 array batteries 1.3 kWh Valve Regulated controller ProStar-30C Morningstar

TR-812 SB Trace Engineering inverter loads Lights and Small Appliances

Water Pumping







Bureau of Land Management • National Park Service • USDA Forest Service







ARIZONA

Phoenix District

Burro Creek Recreation Site



Bruce Asbjorn

Contact Person

(520) 757-3161

Contact Number

\$6,700

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

March 1998

Installation Date

System Components:

array 768 W Solarex

controller Solarjack

loads Solarjack Pump SCS-10-230

- 200 feet of total dynamic head, 2,400 gallons per day.
- Photovoltaic water supply system replaces existing propane engine generator.





CALIFORNIA

Eagle Lake Resource Area

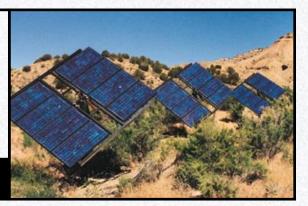
Table Mountain Well



COLORADO

Grand Junction
District

East Desert Well



Don Wannebo

Contact Person

(916) 257-0456

Contact Number

\$4,000 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

July 1998

Installation Date

System Components:

array 384 W Solarex MSX-64

controller Solarjack

loads Solarjack Pump SCS-2-280

General Comments:

• 200 feet of total dynamic head, 750 gallons per day.

Gordon Gardunio

Contact Person

(970) 244-3186

Contact Number

\$13,000 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

May 1998

Installation Date

System Components:

array 1,536 W Solarex MSX-64

controller Solarjack other Tracker

loads Solarjack Pump SCS-8-400

- 330 feet of total dynamic head, 3,200 gallons per day.
- Tracking array.
- · Water for livestock use.





MONTANA

Butte District

Mine Shaft Spring



Applied Power Corporation

System Supplier

(406) 494-5059 Bureau of Land Management

Contact Number System Installer

\$3,300 (hdwr. & pump only) April 1

PV System Cost

Contact Person

Kent Satterlee

April 1996

Installation Date

System Components:

array 200 W Solarex controller Grundfos SA-100

loads Grundfos Submersible Pump

General Comments:

• 15 feet of total dynamic head, 3000 gallons per day.

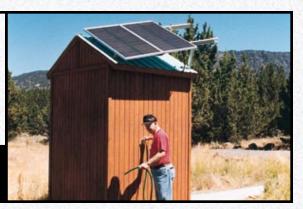
Wildlife and livestock water pumping.

• System pumps water from abandoned mine shaft.

OREGON

Burns District

South Steens Campground



Fred McDonald

Contact Person

(541) 573-4453

Contact Number

\$4,200 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

July 1997

Installation Date

System Components:

array 200 W Duravolt loads Solarjack Pump

General Comments:

• Two identical systems in the campground.

• Pumps water from 200 ft. well.

 Water stored in a 600 gallon tank inside well house for camp ground use - no chlorination.





OREGON

Spokane District



Washburn Lake

Gene Wehmeyer

Contact Person

(509) 665-2100

Contact Number

\$6,000 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

April 1996

Installation Date

System Components:

array 256 W Solarex

controller Solarjack other Fixed Array

loads Solarjack Pump SCS-18-160

General Comments:

 Water requirement 3,000 gallons per day at 30 feet total dynamic head. Trough storage 4,000 gallons for 3 days.

 Water is pumped from Washburn Lake and is stored in a ring trough system.

 Water is provided to livestock. By excluding livestock from the lakeshore, an endangered plant species is protected. **UTAH**

Cedar City District



Holtz Creek

Paul Chamberlain

Contac Person

(801) 865-3053

Contact Number

\$3,700 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

September 1998

Installation Date

System Components:

array 384 W controller Solarjack

loads Solarjack Pump SCS-10-90

- 65 feet total dynamic head, 4,500 per day.
- · Seasonal use.
- This system pumps water out of a drainage for livestock consumption.





UTAH

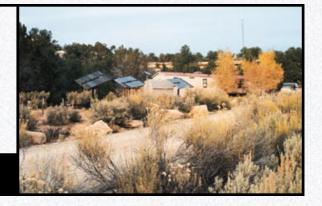
Cedar City District



Sheep Hollow

UTAH

Moab District



Kane Gulch

Mary Casady

Contact Person

(801) 644-2672

Contact Number

\$12,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

May 1997

Installation Date

System Components:

array 1,024 W Solarex

batteries 1,590 A-h Gel-8-G-82

controller 20 Prostar

loads Solarjack Diaphragm Pumps (2)

General Comments:

• 200 feet of total dynamic head.

- Low yield well-system pumps 2 gallons/minute, 24 hrs/day.
- Water is used by livestock and wildlife.
- · Seasonal use.

Trent Duncan

Contact Person

(801) 539-4090

Contact Number

\$20,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 2,000 W Solarex

controller Grundfos

loads Grundfos Submersible Pump

- 350 feet total dynamic head; 2000 gallons per day.
- 10,000 gallon storage tank.
- Seasonal use, April to November.





UTAH

Richfield District-**Fillmore Field** Office





UTAH

Richfield District-Fillmore Field Office

Headquarters



Tom Memmott

Contact Person

(435) 743-3100

Contact Number

\$3.900

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

February 1998

Installation Date

System Components:

384 W Solarex array Solarjack controller

Solarjack Pump SCS-8-90 loads

General Comments:

- 100 feet of total dynamic head, 2,000 gallons per day.
- Seasonal use for livestock water pumping.
- Mechanical wind pump replacement.

Tom Memmott

Contact Person

(435) 743-3100

Contact Number

\$8,200

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

1,152 W Solarex array

Solarjack controller

Solarjack Pump SCS-14-160 loads

- 140 feet total dynamic head, 3,600 gallons per day.
- Two miles pipeline.
- Replaces propane engine generator.
- · Water for livestock use.





UTAH

Richfield District-**Fillmore Field** Office





UTAH

Richfield District-Fillmore Field Office

Sugarloaf



Tom Memmott

Contact Person

(435) 743-3100

Contact Number

\$3.900

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

September 1997

Installation Date

System Components:

384 W Solarex array Solariack controller

Solarjack Pump SCS-8-190 loads

General Comments:

- 100 feet of total dynamic head, 2,000 gallons per day.
- Seasonal use for livestock water pumping.
- Mechanical wind pump replacement.

Tom Memmott

Contact Person

(435) 743-3100

Contact Number

\$3,000

PV System Cost

Photocomm

System Supplier

Photocomm/BLM

System Installer

September 1997

Installation Date

System Components:

256 W Solarex array

controller Solarjack

Zomeworks Tracker other

loads Solarjack DC Submersible Pump

- Pumps 2,500 gallons per day from 50 feet of total dynamic head.
- Wind mechanical water pump replacement.
- Installation served as a training course for BLM personnel to install eight other pumping systems in BLM Districts.





UTAH

Richfield District-Fillmore Field Office

Weather Station/ Rain Gauge



UTAH

Richfield District-Fillmore Field Office



12-A

Larry Maxfield

Contact Person

(801) 539-4059

Contact Number

\$200

PV System Cost

Campbell Scientific

System Supplier

Bureau of Land Management

System Installer

June 1997

Installation Date

System Components:

array 10 W Solarex

batteries 9 A-h Valve Regulated Gel loads Weather Station Rain Gauge

General Comments:

 Six identical systems provide power for data collecting equipment. Tom Memmott

Contact Person

(435) 743-3100

Contact Number

\$6,600

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 768 W Solarex

controller Solarjack

loads Solarjack Pump SCS-14-160

General Comments:

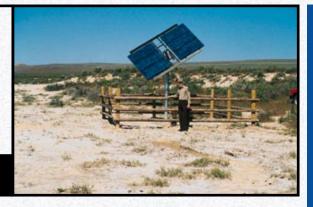
• 750 feet of total dynamic head, 3,000 gallons per day.





UTAH

Salt Lake District



Salt Wells

Kirk Gardner

Contact Person

(801) 977-4397

Contact Number

\$4,000 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

September 1997

Installation Date

System Components:

array 384 W Solarex controller Solariack

loads Solarjack Pump SCS-14-70

General Comments:

• 20 feet total dynamic head; 10,000 gallons per day.

WYOMING

Casper District

Cottonwood Creek Drainage



Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$4,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

September 1996

Installation Date

System Components:

array 120 W Solarex

batteries 12 V Valve Regulated GNB

loads Groundwater Monitoring Equipment

General Comments:

• Project consists of six monitoring sites: one climate station, one large basin stream, and four small basin stream gauges.





WYOMING

Casper District



Coyote Well

Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$6,000

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

Under Construction

Installation Date

System Components:

array 800 W Solarex

controller Solarjack

loads Solarjack Pump

WYOMING

Casper District

Ed O. Taylor Game Range



Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$5,139 (hardware only)

PV System Cost

Photocomm

System Supplier

Bureau of Land Management

System Installer

August 1997

Installation Date

System Components:

array 576 W Solarex

controller Solarjack

loads Solarjack Pump





WYOMING

Casper District

Lonetree Well



Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$15,000 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

August 1997

Installation Date

System Components:

array 1,920 W Solarex

controller Grundfos

inverter Grundfos SA-1500 loads Grundfos Pump

General Comments:

- Groundwater pumping system with 230 feet of total head providing 6,000 gallons of water per day.
- · Summer use for livestock and wildlife.
- Water distributed via 4 miles of pipeline to three pastures.

WYOMING

Casper District

Powder River Basin



Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$1,200 (hardware only)

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

September 1996

Installation Date

System Components:

array 120 W Solarex

batteries Valve Regulated GNB

loads Groundwater Monitoring Equipment

- Project includes solar powering of nine groundwater monitoring sites.
- Each site has a 10-watt panel and an 18 A-h battery powering datalogger equipment.
- Six sites are proposed to utilize radio telemetry, requiring additional 10-watt panel and a 10 A-h battery.





WYOMING

Casper District

Rattlesnake #1

Mike Brogan



Photocomm

Contact Person System Supplier

(307) 234-1525 Bureau of Land Management

Contact Number System Installer

\$7,615 September 1997

PV System Cost Installation Date

System Components:

array 830 W Solarex

controller Solarjack

loads Solarjack Pump

General Comments:

- Groundwater pumping system with 430 feet total head providing 500 gallons of water per day.
- · Summer use for livestock and wildlife.

WYOMING

Casper District

Rattlesnake #2



Mike Brogan

(307) 234-1525

Contact Number

Contact Person

\$12,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

September 1997

Installation Date

System Components:

array 1,920 W Solarex

controller Grundfos

inverter Grundfos SA-1500 loads Grundfos Pump

- Groundwater pumping system with 160 feet of total head providing 7,000 gallons of water per day.
- Summer use for livestock and wildlife.





WYOMING

Casper District

Rattlesnake #3



Photocomm

System Supplier

(307) 234-1525

Mike Brogan

Contact Number

\$11,000

Contact Person

PV System Cost

Bureau of Land Management

System Installer

August 1996

Installation Date

System Components:

array 1,328 W Solarex

controller Solarjack

other Zomeworks Trackers (2)

loads Solarjack Pump

General Comments:

- Groundwater pumping system with 260 feet of total head providing 1,800 gallons of water per day.
- Summer use for livestock and wildlife.

WYOMING

Casper District

Wilderness Well



Mike Brogan

Contact Person

(307) 234-1525

Contact Number

\$10,000

PV System Cost

Southwest PV Systems

System Supplier

Bureau of Land Management

System Installer

September 1997

Installation Date

System Components:

array 1,536 W Solarex

controller USPC Aerovironment

loads Grundfos Pump

- Groundwater pumping system with 160 feet total head providing 1,500 gallons of water per day.
- · Winter use for livestock and wildlife.
- Project supporters also include Rocky Mountain Elk Foundation and Wyoming Game and Fish.





WYOMING

Rawlins District



Chicken Springs

Andy Warren

Contact Person

(307) 328-4271

Contact Number

\$7,000

PV System Cost

Applied Power Corporation

System Supplier

Bureau of Land Management

System Installer

June 1997

Installation Date

System Components:

array 616 W Solarex MSX-77

controller Grundfos SA-1500 Pump Controller loads Grundfos 1.5 HP Submersible Pump

other Trailer Mounted

General Comments:

- Portable pumping system pumps from three different wells in the Red Desert of south-central Wyoming.
- Seasonal use from April thru October.
- Pumps 2,000 gallons of water per day.
- Supplies water for wild horses to improve riparian habitat on Stewart Creek.
- No problems during first two years of operation.







CALIFORNIA

Yosemite National Park

> Backcountry Trail Crew



Korwin Kirk

Contact Person

(209) 372-0550

Contact Number

\$4,600

PV System Cost

Solar Electric Specialties

System Supplier

National Park Service

System Installer

July 1996

Installation Date

System Components:

array 60 W Solarex MSX-30L

batteries 2.2 kWh Solar Cell Valve Regulated

controller Prostar

loads Shurflo 9300 Submersible Pump

General Comments:

- Two systems in use by trail maintenance crews in remote wilderness areas.
- Portable systems transported by mules.
- Systems avoid substantial damage to bank areas of lakes, streams and rivers associated with human and stock access.





CALIFORNIA

Yosemite National Park

Merced Lake



FLORIDA

Biscayne National Park

Boca Chita



Korwin Kirk

Contact Person

(209) 372-0550

Contact Number

\$31,000

PV System Cost

Solar Electric Specialties

System Supplier

National Park Service

System Installer

October 1997

Installation Date

System Components:

660 W Siemens array

Valve Regulated Gel-Type batteries U2624 Trace Engineering, 24 V inverter other Tracker, Wattsun 12-Panel

A.Y. McDonald Submersible Pump loads

General Comments:

• Total project cost was \$51,000 including plumbing, pump, tankage, and hardware.

• Pump is used to pump septic tank effluent to disposal area.

Sheryle Lindley

Contact Person

(305) 247-7275

Contact Number

\$20,000

PV System Cost

Benson Electric

System Supplier

National Park Service

System Installer

April 1996

Installation Date

System Components:

900 W Solarex array

Valve Regulated Johnson Controls batteries

controller Currin SPSC-36B generator 2 kW Propane

loads A.Y. McDonald Pump





HAWAII

Haleakala National Park



Kipahulu

Frank Baublits

Contact Person

(808) 572-4420

Contact Number

\$33,000

PV System Cost

Laf Young and Associates

System Supplier

Laf Young and Associates

System Installer

August 1996

Installation Date

System Components:

array 2,000 W Siemens

loads DC-Motor Driven Water Pump, 3 hp

General Comments:

• Pumps 3,000 gallons per day from head of 330 feet.

• Supplies water to visitor center and campground.

NORTH CAROLINA

Blue Ridge Parkway

Jeffress Park



Cliff Northrup

Contact Person

(704) 298-2828

Contact Number

\$15,000

PV System Cost

Atlantic Solar Products

System Supplier

National Park Service

System Installer

October 1997

Installation Date

System Components:

array 960 W Kyocera KC80

batteries PVC-1295 Valve Regulated Sunmate other Solarjack PCB8-1208 Pump Controller

loads Solarjack Well Pump, 1 hp

General Comments:

• Separate system for building lighting and chlorinator.







ALABAMA

Tuskegee National Forest

> Pine Glen Campground



William Yates

Contact Person

(334) 727-2652

Contact Number

\$20,000

PV System Cost

Photocomm

System Supplier

Tuskegee National Forest

System Installer

May 1996

Installation Date

System Components:

array 1,275 W Solavolt 8500

controller A.Y. McDonald

loads A.Y. McDonald Submersible DC 90 V Pump





ARIZONA

Prescott National Forest





Tonto National Forest

ARIZONA

Cholla Campground



Tim Mabery

Contact Person

(520) 567-4121

Contact Number

\$8,000 (hardware only)

PV System Cost

Photocomm

System Supplier

Tonto National Forest

System Installer

August 1996

Installation Date

System Components:

array 1,080 W Solec S90 controller SCS Solarjack

other Zomeworks Solar Tracker

loads Solarjack SCS II-210 Submersible Pump

Andrew Dziobek

Contact Person

(602) 225-5319

Contact Number

\$40,000

PV System Cost

Photocomm

System Supplier

Tonto National Forest

System Installer

May 1990

Installation Date

System Components:

array 2,304 W Solarex MSX-64 controller PCB8-180C Solarjack

other Zomeworks Solar Trackers (3)

loads 3 H.P. 180 V DC Motor Jensen Pump

General Comments:

 The system provides water for full service campground: flush toilets, showers, hydrants for up to 2,000 people per day.





ARIZONA

Tonto National Forest

Rattlesnake Cove



ARKANSAS

Ozark/St. Francis National Forest

Richland Creek Campground



Andrew Dziobek

Contact Person

(602) 225-5319

Contact Number

\$43,000

PV System Cost

Solar Exchange

System Supplier

Solar Exchange

System Installer

December 1995

Installation Date

System Components:

array 2,304 W Solarex MSX-64

controller PCB8-180 Solarjack

other Zomeworks Solar Trackers (3)

loads Lights, Fans, Water Pump (Jack Pump)

General Comments:

• The system provides water for day use area site: flush toilets, hydrants for up to 420 people per day.

Ken Clements

Contact Person

(501) 964-7251

Contact Number

\$2,600

PV System Cost

Applied Power Corporation

System Supplier

Ozark/St. Francis National Forest

System Installer

May 1996

Installation Date

System Components:

array 120 W Solarex MSX-60

batteries 12-5000 Valve Regulated GNB controller PPC-24 Specialty Concepts Inc.

other Solarjack Pump SDS-D-228





IDAHO

Sawtooth National **Forest**

Raft River Riparian Improvements



KANSAS

Cimarron National Grassland

Cottonwood Picnic Ground



James Chard

Contact Person

(208) 678-0439

Contact Number

\$6,000

PV System Cost

Dankoff Solar Products, Inc.

System Supplier

Dankoff Solar Products, Inc.

System Installer

October 1996

Installation Date

Tim Higgins

Contact Person

(316) 697-4621

Contact Number

\$2,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

June 1996

Installation Date

System Components:

280 W Solec S70 array

#MK1/B Sunrise Submersible Solar Pump controller

Mechanical Tracker other

System Components:

60 W Solarex MSX-60 array

12-5000X Valve Regulated GNB batteries

controller Prostar 20 Morningstar loads

Shurflo 9300 Booster Pump





UTAH

Manti-LaSal National Forest

Mammoth Station



WEST VIRGINIA

Monongahela National Forest

Spruce Knob Campground



Kathy O'Brian

Contact Person

(801) 637-2817

Contact Number

\$12,000

PV System Cost

Applied Power Corporation

System Supplier

Applied Power Corporation

System Installer

October 1995

Installation Date

Mary Smakula
Contact Person

Contact I cisoi

(304) 636-1800

Contact Number

\$2,235 (hardware only)

PV System Cost

Atlantic Solar Products

System Supplier

Monongahela National Forest

System Installer

September 1998

Installation Date

System Components:

array 462 W Solarex MSX-77

controller Grundfos SA 400 other Zomeworks Tracker

loads Grundfos Submersible Pump

System Components:

array 154 W Solarex MSX-77 loads Shurflo 9300 Pump

General Comments:

System replaces water handpump.





WISCONSIN

Chequamegon **National Forest**



Wilson Flowage

Art Johnston

Contact Person

(715) 762-5112

Contact Number

\$10,000

PV System Cost

Applied Power Corporation

System Supplier

Chequamegon National Forest

System Installer

September 1996

Installation Date

System Components:

896 W Solarex MSX-56 array batteries 1,600 A-h Absolyte IIP

Powercenter 3 Ananda Power Technologies controller

General Comments:

• This system replaced diesel-powered lake aeration system.

Appendix II

Sample Procurement Specifications

Photovoltaic Power System Photovoltaic Pumping System

PHOTOVOLTAIC POWER SYSTEM

PART 1: GENERAL

1.01 Summary:

A. Provide four photovoltaic (PV) power systems capable of supplying alternating current as specified complete with PV modules, support racks, power panel, inverter(s), equipment supports, related wiring and other items required ready for government installation. The PV power systems will be used to provide electrical power for remote field stations.

1.02 References:

A. National Fire Protection Association:

NFPA 70-96 National Electrical Code

1.03 Submittals:

- A. General: Submittals include design computations, shop drawings, manufacturers' literature, as-built drawings, samples, and maintenance manuals. Deliver submittals to Trent Duncan, P.O Box 45155, Salt Lake City, UT 84145-0155, allow 5 working days for review.
- B. Required submittals: Submit 2 copies of the following:
 - 1. Electrical diagram and installation drawing of the complete photovoltaic power system showing all major components provided, conductor sizes, types and lengths.
 - Submit catalog data on all equipment with complete description of components; including photovoltaic modules, batteries, inverter, power panel, panelboard, mounting hardware, fuses, cables, conductors, connectors, and all other related equipment.
 - 3. Detailed operation and maintenance manual of complete photovoltaic system as outlined in operation and maintenance data.

1.04 Quality Assurance:

A. Installation and equipment shall comply with all applicable codes, including but not limited to Articles 690, 480 and 250 of the 1996 NEC. All products that are listed, tested, identified, or labeled by UL, FM, ETL, or other national testing organization shall be used when available. Non-listed products are only permitted when listing does not exist.

1.05 Operation and Maintenance Data:

A. Data shall be on 8 1/2 inch by 11 inch sheet or manufacturer's standard catalog, suitable for side binding. Include full product documentation from manufacturer, installer, and/or supplier including, but not limited to, the following items:

1. POWER PANEL AND INVERTER:

- a. Owners manual with programming and installation instructions.
- b. Emergency operating procedures.
- c. Default program values and setpoints.
- d. Listing of field programmed variables and setpoints.
- e. Equipment wiring diagrams.
- f. Product model number, with name, address, and telephone number of local representative.
- g. Starting, operating, and shut down procedures. Include normal, seasonal, and emergency shut down procedures.
- h. Schedule of maintenance work, if any.
- Replacement parts list, including internal fuses.
- j. Warranty paperwork.

2. BATTERIES:

- a. Owners manual with installation, testing and charging instructions. Instructions shall be very specific as to how the batteries shall be maintained and operated in order to ensure long-life.
- Emergency operating procedures, including method of handling leaking or damaged battery.
- c. Recycling and salvage information.
- d. Product model number, with name, address, and telephone number of local representative.
- e. Starting, operating, shut down procedures. Include seasonal shut down and storage.
- f. Schedule of maintenance and testing.
- g. Warranty paperwork.
- 3. PHOTOVOLTAIC MODULES, PANELBOARDS, SWITCHES, CKT BREAKERS, AND BALANCE OF SYSTEM COMPONENTS:
 - a. Owners manual or manufacturer's product data sheet, as applicable.
 - b. Equipment wiring diagrams.
 - c. Product model number, with name, address, and telephone number of local representative.
 - d. Starting, operating, and shut down procedures. Include normal, emergency, and seasonal shut down procedures.
 - e. Schedule of maintenance work, if any.
 - f. Replacement parts list, including fuses, diodes, etc.
 - g. Warranty paperwork.
 - h. Cleaning agents and methods.

PART 2: PRODUCTS

2.01 Conductors:

A. As specified in this section, and as recommended by the equipment manufacturer. All conductors shall be sized based on a maximum 3% voltage drop.

2.02 Photovoltaic Modules:

- A. General: Modules shall be UL, FM, or ETL listed. High-power type, with typical peak power of not less than 64 watts at standard test conditions. Voltage at peak power shall not be less than 17.5 Vdc. Current at peak power shall not be less than 3.66 amps. Model #MSX-64 as manufactured by Solarex or approved equal (see Equipment Summary Table for quantities).
- B. Units shall have 20-year limited warranty guaranteeing:
 - 1. That no module will generate less than its specified minimum power when purchased.
 - 2. Continued power of at least 80% of guaranteed minimum power for twenty years.
- C. Splices: All splices shall be made in approved junction boxes with an approved accessible splicing method. Terminal strips, and boxtype pressure connectors are approved splicing methods. Twist-on "wire nuts" are not allowed.
- D. Module Interconnections:
 - 1. Module interconnection wiring shall be 90°C type USE-RHH-RHW sunlight resistant, suitable for exposed use, tray cable, or liquid tight flexible metal conduit with appropriately rated conductors. Minimum size of #10 awg unless otherwise indicated.
 - 2. Interconnection wiring for series and parallel modules shall include a terminal

- strip, splicing block, or bus bar arrangement so that one source circuit can be disconnected without disconnecting the grounded conductor(s) of other source circuits. Daisy chaining modules together is not permitted.
- 3. Array shall be divided into a minimum of two similar sized sub-arrays. Separate disconnects for each sub-array shall be provided at the powerpanel.
- 4. A 6 amp bypass diode shall be provided for each module.
- 5. Array grounding means shall be provided and shall be connected to the system ground.
- E. Transition wiring: Wiring from the PV array (junction box of first module) to the combiner/jbox shall be 90°C type USE-RHH-RHW sunlight resistant wire as listed above. Minimum wire size of #10 awg unless otherwise indicated.
- F. Mounting structure: Module mounting type shall be as specified in the Equipment Summary Table.
 - 1. Roof mounting structure shall be corrosion resistant and fabricated from aluminum alloys with stainless steel fasteners. Panel rails shall be as recommended by module manufacturer. Each structure shall be capable of holding 4 or 6 of the required modules at a tilt specified in the Equipment Summary Table.
 - Pole mount structure: Module support structures shall be a fixed mount on the top of a SCH 40 pipe mast furnished and installed by the government. Each rack shall hold 8 or 12 modules in a fixed position. Mast spacing and size to be determined by the supplier. A combinerbox shall be affixed to each mast.

G. Array output wiring: Wiring from the combiner/J-box to the power panel shall be of the length specified in the equipment summary table and shall be 90°C type THHN. Required conduit size shall be specified by the supplier in the installation manual but need not be supplied.

2.03 Combiner/J-Box:

A. Hinged cover fiberglass NEMA 4X enclosure as manufactured by Hoffman or approved equal. Unit shall be sunlight resistant, and exhibit excellent chemical temperature, and weather resistance properties. Minimum size of 12" x 10" x 6" with screw cover, or as required per fill calculations.

2.04 Power Distribution Blocks:

A. As required for changing conductors sizes, combining multiple conductors, etc. Rated for voltage and current of system. As manufactured by ILSCO or approved equal.

2.05 Batteries:

- A. General: The batteries shall have the following features and characteristics: (see Equipment Summary Table for quantities).
 - 1. Deka 8G8D valve regulated battery or approved equal. 12 V per battery, minimum 265 amp/hour capacity at the 100 hour discharge rate, 400 cycles @ 50% depth of discharge.
 - Absolyte IIP 3-90A-23 valve regulated or approved equal. 6 V per battery, minimum 1300 amp/hour at the 100 hour discharge rate, 1200 cycles at 80% depth of discharge.
- B. Cables: Factory crimped and soldered ring terminals for battery and inverter bolted connections. Cables shall have identification labels on each end for positive and negative terminal connections.

- C. Terminals: Exposed battery terminals and cable connects must be protected with a cover against potential short-circuiting.
- D. Rack: A battery rack(s) shall be provided which hold 4 batteries on a shelf and up to 3 shelves high (approximately 60" wide, 24" deep and 48" tall). Each shelf shall allow adequate clearance to access battery terminals. Rack shall be easily assembled in the field.

2.06 Disconnects/AC Panel Boards/Etc.:

- A. General: Circuit breaker and switches shall be UL-Listed and DC rated for load controll. Disconnects and over current devices shall be mounted in approved boxes, enclosures, or panelboards. Requirements for internal configuration of these enclosures shall comply w/NEC Article 370, 373, 384 and applicable UL-Standards. Metal enclosures/boxes shall be bonded to the grounding conductor.
 - 1. Panelboards: Provide one AC panel board with each system. Provide equipment ground bar kit. Copper bus required. Provide a main disconnect consistent with inverter capacity and slots for 10 additional breakers. Provide conductors and conduit to facilitate panelboard mounting within 5 feet of powerpanel.
 - Circuit breaker enclosures: Breaker type "QO". Isolated neutral bus required. Include two 15 amp breakers in panelboard. Manufactured by Square-D or approved equal.

2.07 DC Load Center:

- A. General: Model PAC-500AC-48 Vdc as manufactured by Pulse Energy Systems or approved equal. DC power center shall have at a minimum the following features:
 - 1. Unit must be UL listed and compatible

- with 48 Vdc negative ground electrical system.
- 2. Unit shall comply with Article 690-5 of the 1996 NEC.
- 3. Battery/Inverter/Main disconnect: UL listed for up to 125 Vdc @ 250 amps per pole, 2 poles total.
- 5. Circuit breakers UL Listed, DC rated, 5K AIC at 65 Vdc.
- 6. PV charge controller & load disconnect contacts: Mercury displacement type, UL Listed,
- 7. Solar array disconnect with 30 amp breaker & red tripped indicator.
- 8. Battery cable terminal lugs up to 2-#250MCM.
- 9. Inverter cable terminal lugs up to 2/dual #250MCM.
- 10. Automatic array disconnect to eliminate night-time losses.
- 11. LED indicators for battery charging status.
- 12. Smartlight plus battery charge indicator.

B. ADDITIONAL FEATURES:

- LCD digital display unit indicating array input current, load current, and battery voltage, PSM-3 or approved equal. Unit shall fit in door of DC load center cabinet.
- 2. Battery temperature compensator.
- 3. Lightning arrestor.
- 4. Factory calibration of battery charge controller for specified batteries.
- 5. Inverter bypass switch.
- 6. A permanent label shall be posted near the main PV disconnect switch that contains the following information per NEC 690-52:
 - a. Operating current (system's maximum power current).

- b. Open-circuit current.
- c. Operating voltage (system's maximum power voltage)
- d. Open-circuit voltage.
- 7. Furnish all other equipment, conductors, conduit, hardware and appurtenances as specified and/or required for a complete and operable system. A 3/4 inch sheet of exterior grade painted plywood shall be supplied with the mounting locations for DC load center and inverter clearly identified.

2.08 Inverter:

As manufactured by Trace Engineering, Arlington WA 98223 or approved equal. Inverter shall have at a minimum the following features:

- 1. ETL listed.
- 2. Nominal DC input voltage of 48 Vdc, AC output voltage (RMS) of 120 Vac @ 60 Hz.
- 3. Continuous power rating of 4000 VA or 5500 VA @ 20°C.
- 4. Peak efficiency of 96%.
- 5. Automatic AC transfer relay rated at 60 amps.
- 6. Maximum charging rate of 60 amps.
- A. Programming: Unit shall be programmable, with separate user and setup menus. Unit shall have lighted back-lit LCD display on the control panel. The LCD display shall also indicate Inverter Amps, Input Amps, Load Amps, Battery Volts DC, and Inverter Volts AC. Control panel LED's shall report the status of Line-Tie, AC1-In, Bulk, Error, Inverting, AC2 IN, Float & Over current conditions. Recommended settings of each inverter set point shall be summarized in the operation and maintenance manual and on a laminated card to be placed near the inverter.

- B. Operating modes: The inverter shall be capable of parallel operation with the existing AC generator. The inverter shall synchronize its output waveform with that of the AC input source. The inverter shall function in the following modes for this project:
 - 1. Generator auto-start mode: Unit shall be capable of automatically starting the generator when battery voltage drops at or below 80% depth of discharge (as published by battery manufacturer). A "quiet-time" feature shall also be built into the unit to restrict generator operation during programmed time periods.
 - 2. Generator support mode: When charging batteries from a generator, the inverter shall be capable of monitoring the generator's output voltage and current. If the voltage or current falls outside user adjustable limits, the inverter shall shed itself as a load and reverse power flow if necessary to assist the generator.
 - 3. Battery charger mode: Unit shall have three stage temperature compensated charging algorithm for charging batteries. Unit shall have remote battery temperature probe. Unit shall operate in manual equalize mode with adjustable settings. Unit shall have automatic "Back-Off" system to prevent overloading of generator or nuisance tripping of input breakers.
 - 4. Inverter mode: Unit shall have low battery cutout voltage with adjustable time delay to prevent damaging batteries. Unit shall have protection circuitry against over-current, short circuit, over temperature, low battery voltage and high battery voltage conditions.

2.09 Grounding:

- A. Maintain a single point, negative ground throughout the PV system. Array shall be included in the grounding system.
- System grounding shall be according to the NEC and include 15 feet of properly sized grounding conductor, ground rod and clamp.

2.10 Equipment Summary Table:

The following table provides a summary of the photovoltaic equipment required under this contract. Additional items and equipment are required to make the system complete and functional.

Site	Pariette	Chicken	Mt. Trumbull	Mud Flat
# Modules	16	20	40	32
Batteries Qty./ Model #	8/8G8D	8/8G8D	8/3-90A-23	12/8G8D
Inverter Size (continuous power rating)	4.0 kW	4.0 kW	11 kW (Dual Inverter)	5.5 kW
Output Voltage	120 Vac	120 Vac	120/240 Vac	120 Vac
Array Mount Tilt	Roof/20°1	Roof/64 ⁰¹	Pole	Pole
Array Output Cable Length	50 feet	35 feet	60 feet	60 feet
Battery Cable Length	15 feet	10 feet	15 feet	10 feet
Delivery Location	Vernal Field Office 170 S. 500 East Vernal, UT 84078	Tok Field Office P.O. Box 309 Tok, Alaska 99780	Arizona Strip Field Office 345 E. Riverside Dr. St. George, UT 84790	Boise Field Office 3948 Development Ave. Boise, ID 83705-5389
Contact	John Wood (435) 781-4400	Kent Davis (907) 883-5121	Ken Moore (435) 628-4491	Bob Stucker (208) 384-3300

¹Elevate mount 6 inches above roof to clear standing seam of metal roof.

PHOTOVOLTAIC PUMPING SYSTEM

C.1 GENERAL

C.1.1 Summary:

- A. Provide photovoltaic (PV) water pump systems capable of supplying the specified quantities of water complete with modules, support rack, disconnects, controller, motor/pump unit, related wiring and other items required ready for government installation. The systems shall operate automatically, with no user attention during daylight hours. They shall pump water proportional to the amount of incident sunlight.
- B. Work data: All pumps will be located within 50 miles of Delta, Utah except pump #6, Holtz Creek, which will be located near Cedar City, Utah, pump #7 which will be located near Grand Junction, Colorado, pump #8 which will be located near Salt Lake City, Utah, and pump #9 which will be located near Kingman, AZ.

Name	TDH	Minimum GPD	Season
1. 12-A	75'	3,000	Winter
2. Headquarters	20'	3,600	Summer
3. Sugarloaf	50'	2,500	Summer
4. Delta #1	100'	2,000	Summer
5. IPA	100'	2,000	Summer
6. Holtz Creek	65'	4,500	Summer
7. East Desert	330'	3,200	April-Sept.
8. Salt Wells	20'	10,000	Summer
9. Burro Creek	200'	2,400	Summer

C.1.2 Submittals:

A. General: Submittals shall be sent to Contracting Officer, P.O. Box 45155, Salt Lake City, UT 84145-0155. Submittals shall be approved by the Contracting Officer prior to delivery of systems.

- B. Manuals: An installation, operating, maintenance and user manual shall be included with each system.
 - 1. Installation, operating and maintenance instructions: Submit 1 copy of installation, operation and maintenance manuals, intended for service personnel. The manuals shall include recommended acceptance test procedures, a schedule of preventative maintenance procedures, a suggested spare parts list, a trouble shooting index, all component manufacturers specifications sheets, recommended drop caple and drop pipe size, and a set of mechanical drawings and electrical schematics. These drawings must include identification of all PV system components, electrical interconnections, conductor types, sizes, and color coding, fuse, circuit breakers and switch types/ ratings, and any other related information. The system sizing and performance (estimated daily water output in gallons per day) calculations over a 12 month period shall also be included.
 - 2. Users manual: Submit 1 copy of a separate users manual intended for system operator. The manual must include all information pertaining to the proper use of the system, including a basic system theory of operation, specific instructions on the use of the system monitoring equipment, a user trouble shooting guide, and a discussion on any load limitations.

C.2 PRODUCTS

C.2.1 Equipment:

- A. General: PV pumping system shall meet the requirements of the NEC articles 690 and all other applicable articles to ensure installer/operator safety. Equipment shall be UL listed where available. All equipment and conductors shall be capable of operating in temperatures of -20°C to 45°C. PV pumping system shall also include the following:
 - 1. A manual electrical disconnect (safety switch) that shuts off power from the PV power supply shall include hardware to attach to an array support pole above or below the pump controller.
 - 2. System shall be grounded according to the NEC articles 250 and 690.
- B. Photovoltaic power supply: Power supply shall be complete with PV array, mounting structure, controller, and any balance of system hardware and conductors required for "above ground" installation. The power supply shall be sized by supplier and be capable of supplying the pump controller proper current and voltage. In each case, the array will be installed within 30 feet of the well head.
 - Photovoltaic modules shall be UL listed and include a minimum 10 year 90% power rating warranty. System #7 shall include a minimum of 1920 rated array watts.
 - 2. Module support structures shall mount either on the top or side of a SCH 40 pipe mast furnished and installed by the

- government. Either passive tracking or fixed array are acceptable except for system #7 which shall include passive tracking racks as manufactured by Zomeworks or equal. Mast spacing and size to be determined by the supplier.
- Bypass diodes shall be installed in modules according to module manufacturers requirements.
- 4. Power supplies must display hazard warning signs where there is a high voltage danger to the installer/operator.
- 5. Controller shall be designed to work specifically with manufacturers motor/ pump unit. Controller shall include hardware required to mount directly to array support pole and shall be in a raintight NEMA enclosure. Controller shall include on/off switch and connection for external float switch.
- C. Submersible motor/pump unit: motor/pump unit shall be multistage, centrifuge type, brushless motor, capable of operating submersed in 50 feet of water. System #7 shall be capable of delivering a maximum of 9.7 gpm and shall include a Grundfos SP2A-15PM submersible pump/motor or equal.
 - 1. Pump and motor materials exposed to water shall be corrosion resistant, and require no maintenance for a 10 year period or more.
 - 2. The pump shall be internally threaded and have a built in check valve and pump inlet screen.
 - 3. Provide two waterproof splice connection kits per pump to connect pump leads to government furnished drop cable.

C.3 DELIVERY

A. Delivery schedule: Systems shall be delivered acording to the following schedule:

System #	Location
1-5	Fillmore Field Office Attn: Tom Memmott (801) 322-3109 35 East 500 North Fillmore, Utah 84631
6	Cedar City Field Office Attn: Paul Chamberlin (801) 865-3014 176 D. L. Sargent Drive Cedar City, Utah 84720
7	Grand Junction District Office Attn: Gordon Gardunio (970) 244-3186 2815 H Road Grand Junction, CO 81506
8	Salt Lake District Office Attn: Riley Draper (801) 977-4300 2370 South 2300 West Salt Lake City, UT 84119
9	Kingman District Office Attn: Bruce Asbjorn (520) 692-4400 2475 Beverly Ave. Kingman, AZ 86401

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NTIS price codes Printed copy: A04 Microfiche copy: A01

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